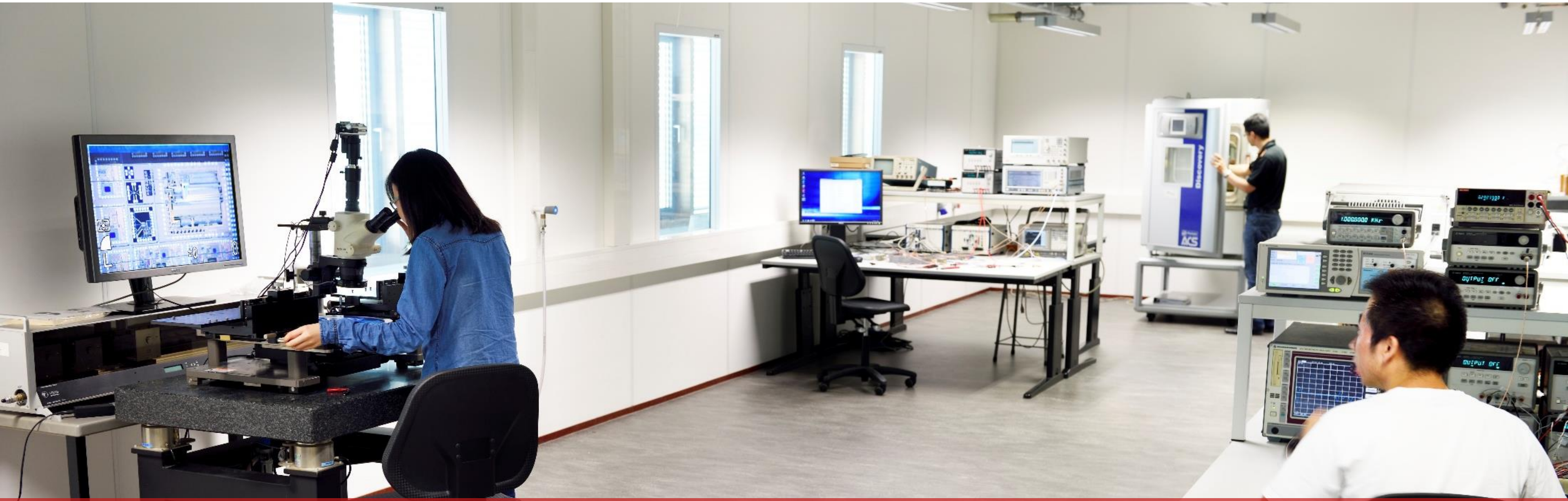
EINDHOVEN UNIVERSITY OF TECHNOLOGY



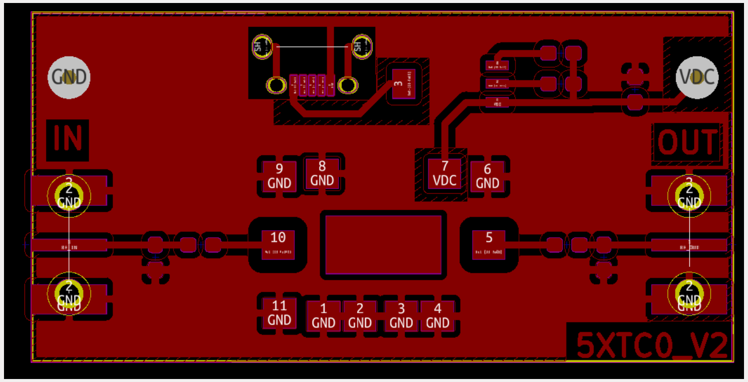
Components in wireless technologies (5XTC0)

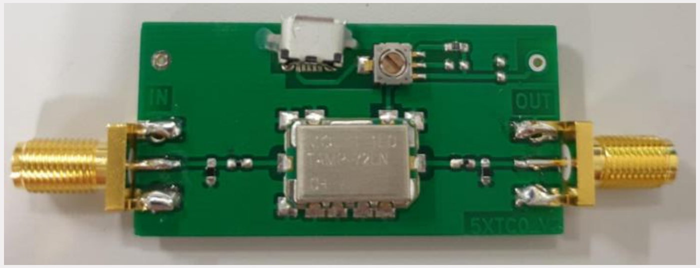
Module 5, Lab QUCS RF Amplifier design/simulation

Rainier van Dommele

Introduction

- Current 5XTC0_V2 Amplifier board:





Includes the Mini-Circuits TAMP-72LN+ amplifier.

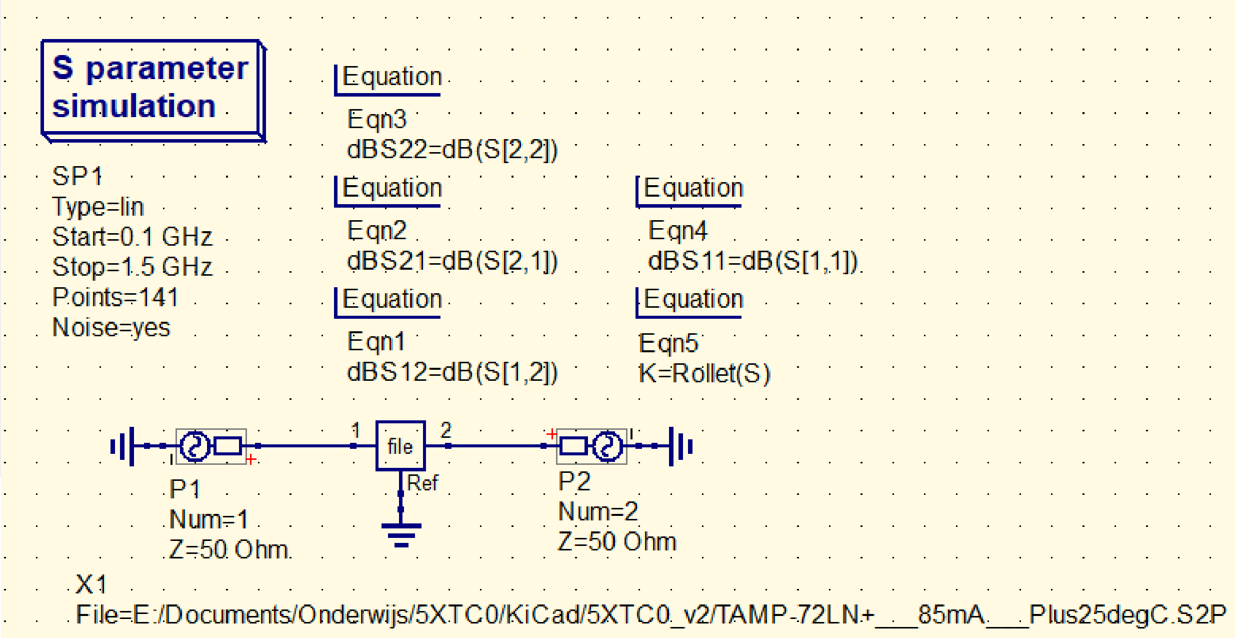
- Assignments for today:
  - simulate the stand-alone amplifier and amplifier board.
  - redesign amplifier board input and output matching circuits using LC components.

Stand-alone amplifier: S parameters simulation

Link to S parameter file of the amplifier:

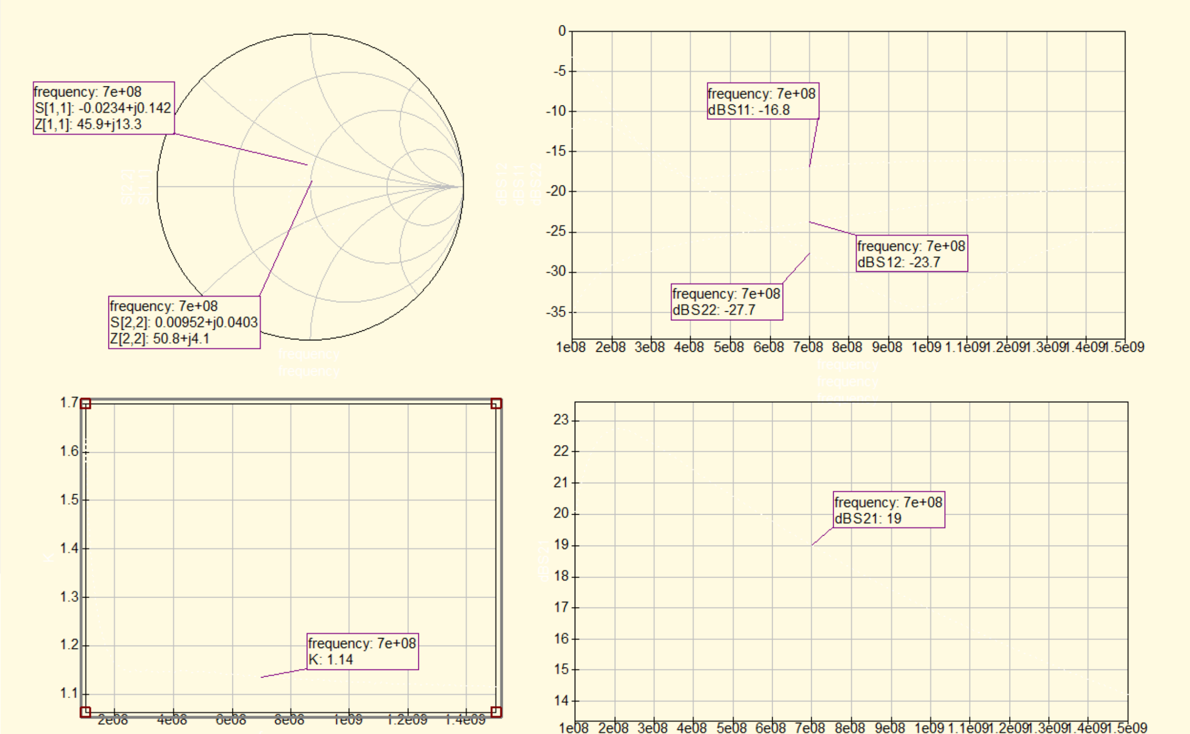
https://www.minicircuits.com/pages/s-params/TAMP-72LN+_S2P.zip OR https://canvas.tue.nl/files/3712855/download?download_frd=1

Task: generate test-bench in QUCS for simulating S parameters of the stand-alone amplifier as shown in figure below.
Use 2-port s-parameter file component to include the S parameters of the amplifier.



Stand-alone amplifier: simulated results

- **Assignment task**
  - **Simulate and plot S11, S12, S21, S22 and K factor**
  - **Provide these results in the answer template**
- **Results should look as in the figure below**



Comparison: simulated data versus amplifier data sheet

Assignment questions, use the answer template.

1. Explain meaning of:
   - S11, S12, S21, S22
   - K factor
2. What is frequency range where amplifier can be used?
3. You did not need to provide biasing, why?

Link to data sheet of amplifier

Compare simulated S parameters and stability factor with information parameters provided in datasheet.

4. Are there any differences?

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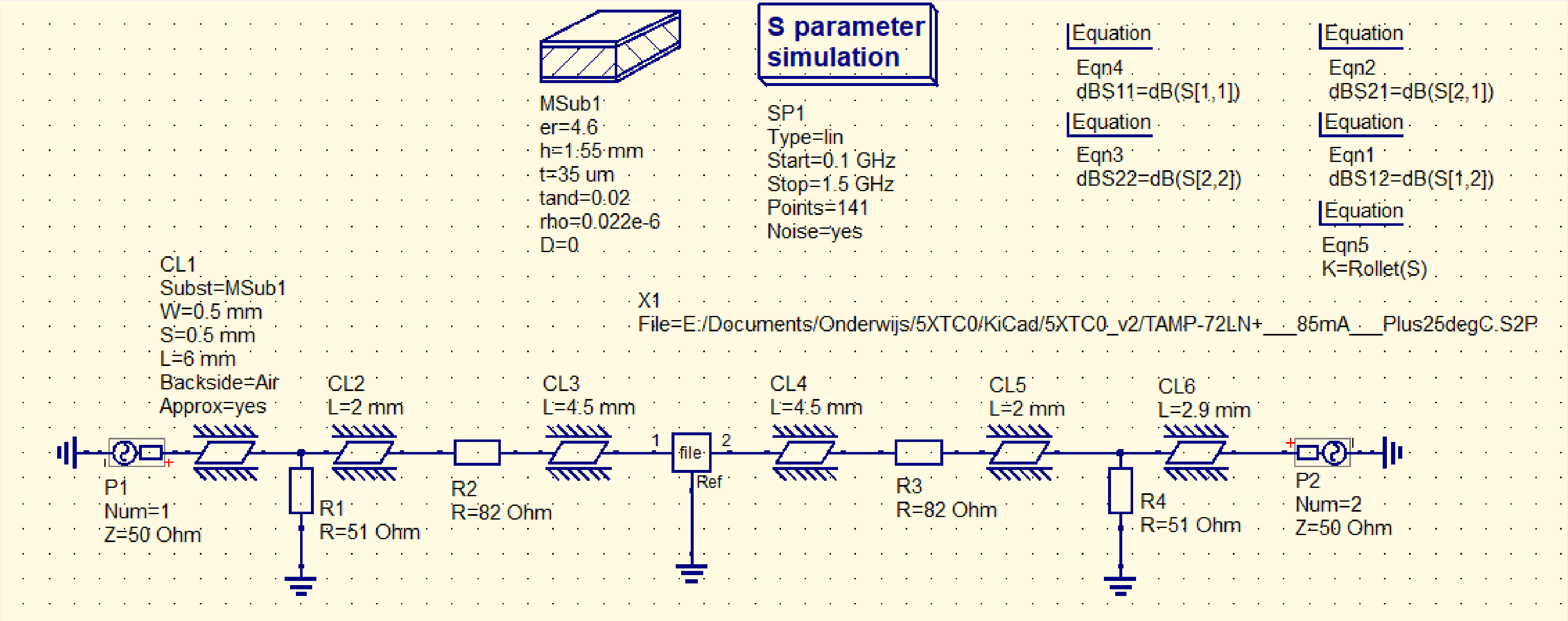
Amplifier board: S parameter simulations

Task: generate test-bench in QUCS for simulating the S parameters of the amplifier board as shown in figure below.



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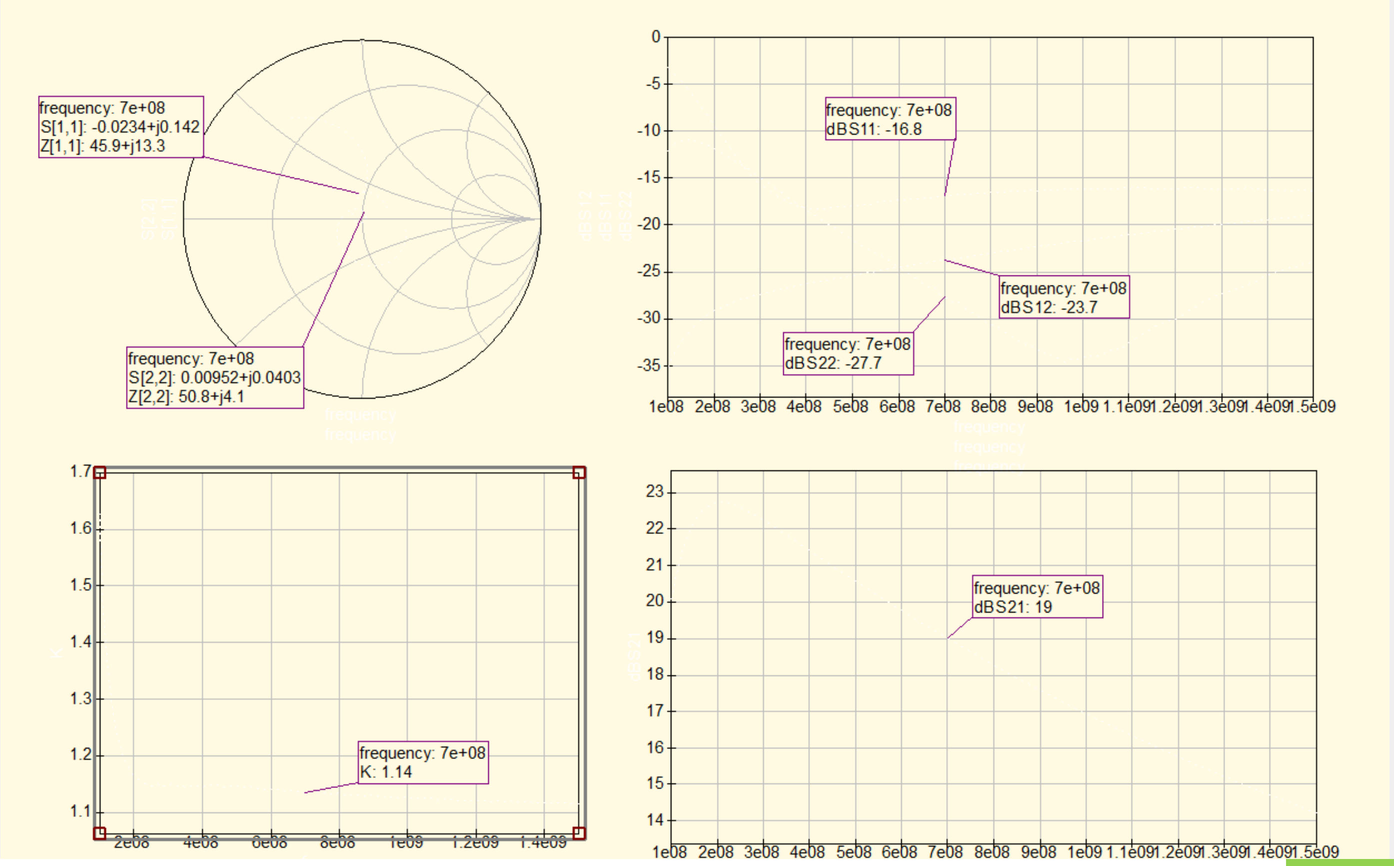
Amplifier board: simulation results

Plot the results in the answer template as shown below.



Difference between stand-alone and amplifier board simulations

We observed differences between simulations of stand-alone amplifier and amplifier board. Explain the differences.
Assignment questions, use the answer template to note your answers.

5. Why do the S11 & S22 change when you have resistors on the amplifier board (compared to the situation where there are only transmission lines and the amplifier)?
6. Why is the S21 (gain) much lower?
7. Why is the stability factor higher?

Assume the frequency of interest is 700 MHz.

8. What is the impedance of the transmission lines (at this frequency)?
9. What should have been "S" (space between transmission line and ground plane) in order to make the transmission line 50 Ohm at this frequency, keeping the width of the transmission line 0.5 mm?

Redesign of Amplifier board

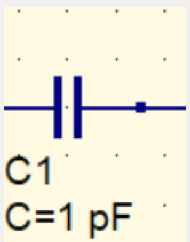
The resistors R1, R2, R3, R4 are to reduce the gain so the NanoVNA can measure this board.
If we now assume this board would not be used with the NanoVNA, but as an amplifier in a transceiver, we would remove the resistors.

Task: Remove the resistors from the schematic and match the amplifier board in such a way that the gain is maximized at 700MHz.
You can use LC matching on the locations of the resistors. To make the assignment simpler, remove CL1, CL2, CL5 & CL6. See next slides.

Capacitor values to use during redesign

Capacitors: 0603 inch size (1608 metric) and E12 series. See screenshot below which values to take. So only realistic values.

You can use the ideal C component.



0603

NP0, 50V	
Value	Tolerance
0.47 pF	± 0.25 pF
0.68 pF	± 0.25 pF
1.0 pF	± 0.25 pF
1.5 pF	± 0.25 pF
2.2 pF	± 0.25 pF
3.3 pF	± 0.25 pF
4.7 pF	± 0.25 pF
6.8 pF	± 0.5 pF
10 pF	± 5 %
15 pF	± 5 %
22 pF	± 5 %
33 pF	± 5 %
47 pF	± 5 %
68 pF	± 5 %
100 pF	± 5 %
150 pF	± 5 %
220 pF	± 5 %
330 pF	± 5 %
470 pF	± 5 %
680 pF	± 5 %

NP0, 25V	
Value	Tolerance
1.0 nF	± 5 %
1.5 nF	± 5 %
X7R, 50V	
Value	Tolerance
100 pF	± 10 %
150 pF	± 10 %
220 pF	± 10 %
330 pF	± 10 %
470 pF	± 10 %
680 pF	± 10 %
1.0 nF	± 10 %
1.5 nF	± 10 %
2.2 nF	± 10 %
3.3 nF	± 10 %
4.7 nF	± 10 %
6.8 nF	± 10 %
10 nF	± 10 %
X7R, 25V	
Value	Tolerance
15 nF	± 10 %
22 nF	± 10 %

X7R, 16V	
Value	Tolerance
33 nF	± 10 %
47 nF	± 10 %
68 nF	± 10 %
100 nF	± 10 %
Y5V, 50V	
Value	Tolerance
10 nF	± 20 %
15 nF	± 20 %
22 nF	± 20 %
33 nF	± 20 %
47 nF	± 20 %
68 nF	± 20 %
100 nF	± 20 %
Y5V, 16V	
Value	Tolerance
150 nF	± 20 %
220 nF	± 20 %
330 nF	± 20 %
470 nF	± 20 %

Inductor values to use (1/2)

Inductors: 0603 inch size (1608 metric).

Use real inductors: [Murata LQW18AN series (link)].

No.	Part Name	
1	LQW18AN2N2D00	2.2nH±0.5nH
2	LQW18AN3N6C00	3.6nH±0.2nH
3	LQW18AN3N9C00	3.9nH±0.2nH
4	LQW18AN4N3C00	4.3nH±0.2nH
5	LQW18AN4N7D00	4.7nH±0.5nH
6	LQW18AN5N6C00	5.6nH±0.2nH
7	LQW18AN6N2C00	6.2nH±0.2nH
8	LQW18AN6N8C00	6.8nH±0.2nH
9	LQW18AN7N5C00	7.5nH±0.2nH
10	LQW18AN8N2C00	8.2nH±0.2nH
11	LQW18AN8N7C00	8.7nH±0.2nH
12	LQW18AN9N1C00	9.1nH±0.2nH
13	LQW18AN9N5D00	9.5nH±0.5nH
14	LQW18AN10NG00	10nH±2%
15	LQW18AN11NG00	11nH±2%
16	LQW18AN12NG00	12nH±2%
17	LQW18AN13NG00	13nH±2%
18	LQW18AN15NG00	15nH±2%
19	LQW18AN16NG00	16nH±2%
20	LQW18AN18NG00	18nH±2%
21	LQW18AN20NG00	20nH±2%
22	LQW18AN22NG00	22nH±2%
23	LQW18AN24NG00	24nH±2%
24	LQW18AN27NG00	27nH±2%
25	LQW18AN30NG00	30nH±2%
26	LQW18AN33NG00	33nH±2%
27	LQW18AN36NG00	36nH±2%
28	LQW18AN39NG00	39nH±2%
29	LQW18AN43NG00	43nH±2%
30	LQW18AN47NG00	47nH±2%
31	LQW18AN51NG00	51nH±2%
32	LQW18AN56NG00	56nH±2%
33	LQW18AN62NG00	62nH±2%
34	LQW18AN68NG00	68nH±2%
35	LQW18AN72NG00	72nH±2%
36	LQW18AN75NG00	75nH±2%

These are samples for evaluation purpose.
Please do not ship out your completed product with the sample

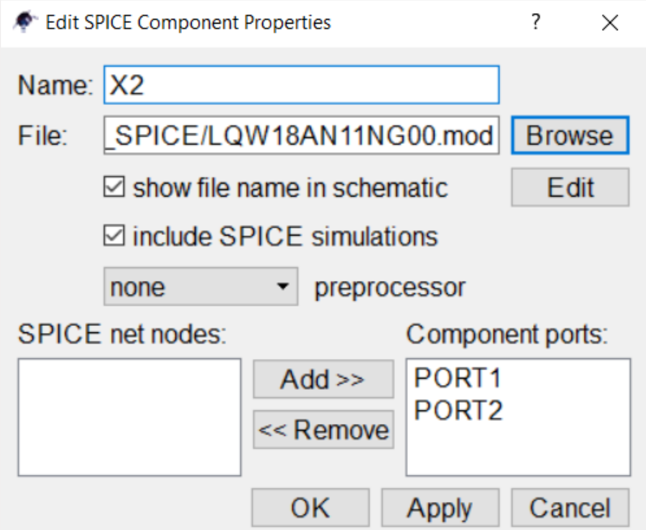
No.	Part Name	
37	LQW18AN82NG00	82nH±2%
38	LQW18AN91NG00	91nH±2%
39	LQW18ANR10G00	100nH±2%
40	LQW18ANR11G00	110nH±2%
41	LQW18ANR12G00	120nH±2%
42	LQW18ANR13G00	130nH±2%
43	LQW18ANR15G00	150nH±2%
44	LQW18ANR16G00	160nH±2%
45	LQW18ANR18G00	180nH±2%
46	LQW18ANR20G00	200nH±2%
47	LQW18ANR22G00	220nH±2%
48	LQW18ANR27G00	270nH±2%
49	LQW18ANR33G00	330nH±2%
50	LQW18ANR39G00	390nH±2%
51	LQW18ANR47G00	470nH±2%
52	LQW18AN2N2D10	2.2nH±0.5nH
53	LQW18AN3N9C10	3.9nH±0.2nH
54	LQW18AN5N6D10	5.6nH±0.5nH
55	LQW18AN6N8C10	6.8nH±0.2nH
56	LQW18AN8N2D10	8.2nH±0.5nH
57	LQW18AN10NG10	10nH±2%
58	LQW18AN12NG10	12nH±2%
59	LQW18AN15NJ10	15nH±5%
60	LQW18AN18NG10	18nH±2%
61	LQW18AN22NG10	22nH±2%
62	LQW18AN27NG10	27nH±2%
63	LQW18AN33NJ10	33nH±5%

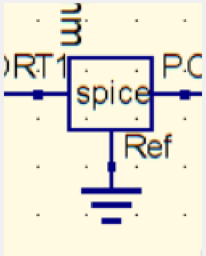
These are samples for evaluation purpose.
Please do not ship out your completed product with the sample

Inductor values to use (2/2)

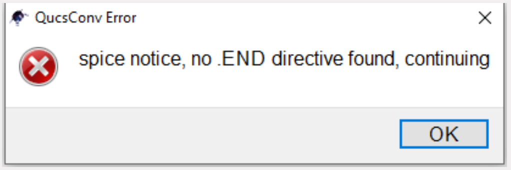
First calculate which ideal inductor value you would use. Then download the spice model of the inductor which has a value closest to the calculated value from [Murata LQW18AN series (link)]().

Place a “file components” -> “spice netlist” item and double click it. Browse to the .mod file and add the ports:





Ignore this error:



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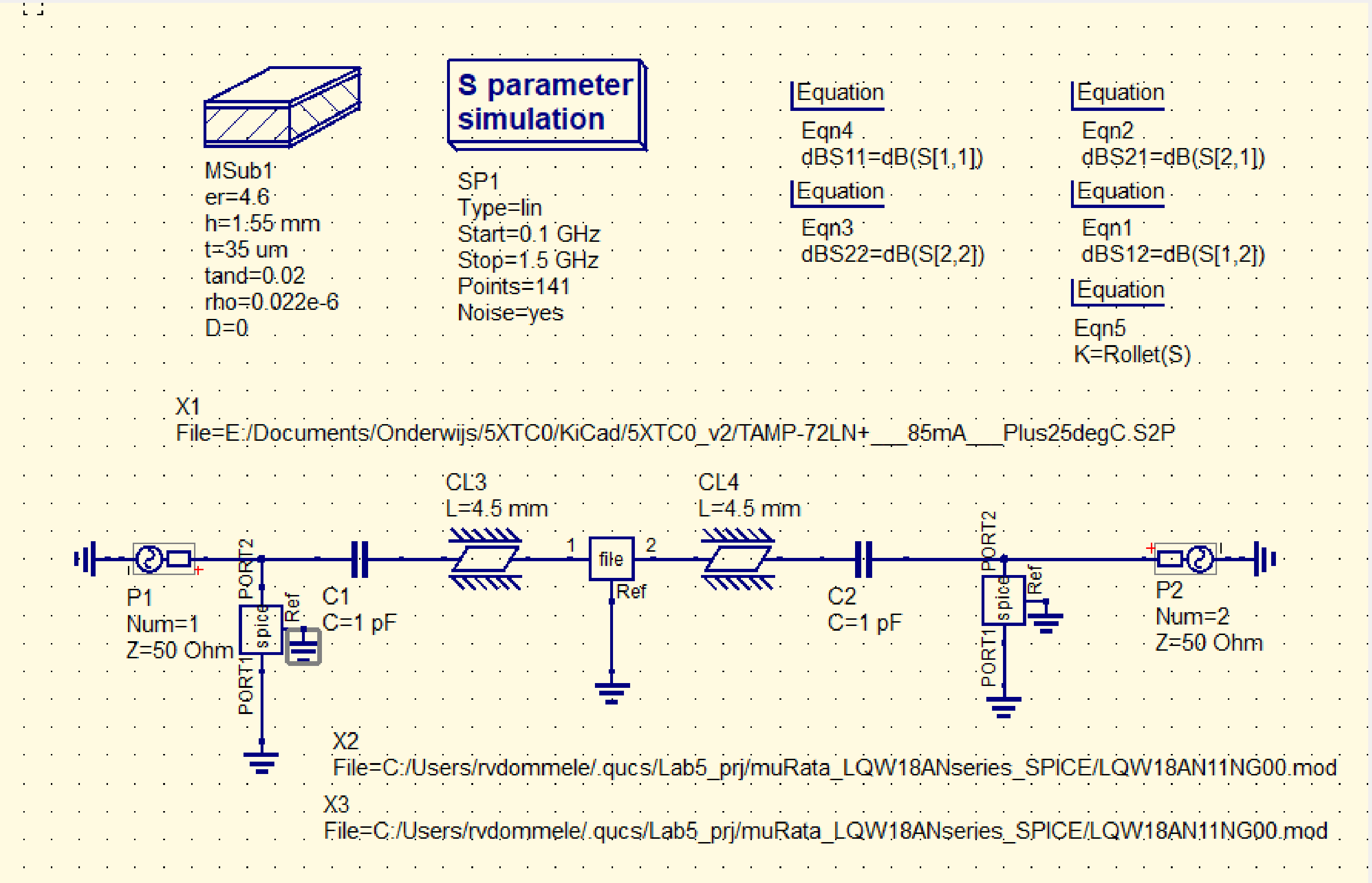
Redesign example with LC matching and transmission lines CL1,2,5,6 removed



Assignments after redesign task

We observe differences between the 5XTC0_V2 amplifier board and your redesigned matching amplifier board. Explain the differences.

Assignment questions, use [the answer template].

10. How high was the gain of the 5XTC0_V2 board originally?
11. And how high is the gain if we remove R1&R4 and short R2&R3 (board without resistors, unmatched)?
12. And how high is the gain with your redesign matched board?
13. What do you notice in the S11 / S22 curves of your redesigned matched board?

Reporting

Upload a small report with your answers of Lab 5 and 6 to Canvas before Friday March 28, 23:59. Use the answer template for this. And please note your name in the file, as well as in the filename.

During the oral exam you'll get questions about the labs.